7th Int. Symp. "Nanostructures: Physics and Technology"
St Petersburg, Russia, June 14–18, 1999

Growth of InAs self-assembled islands on Ge

S. A. Komarov†, G. S. Solomon‡ and J. S. Harris Jr.†
† Solid State and Photonics Laboratory, Stanford University,
Stanford, CA, 94305, USA
‡ Ginzton Laboratory, Stanford University,
Stanford, CA, 94305-4075,USA

Tremendous amount of research has been devoted to the study of quantum confined structures in the several last years. One of the most popular systems that has been extensively investigated is an ensemble of self-assembled coherently strained nano-sized islands. Despite this effort, complete clarity in understanding mechanisms influencing island formation and evolution is lacking. An important aspect which is not resolved yet is the relationship between the kinetics and thermodynamics of island formation; in particular, what roles strain and surface diffusion play in the islanding dynamics.

To this end, we have investigated an unconventional material system: strain-induced InAs islands on Ge. This is the first time that nanoscale islanding in Stransky–Krastanow mode has been observed and characterized in this a material system. An advantage of this system is close lattice constants of GaAs and Ge, and thus, it becomes possible to compare InAs islanding trends in two systems where the strain state is the same but the underlayer material is different. In addition, understanding the InAs island evolution in this system will give more insight into other systems such as InAs islands on Si.

InAs islands were grown by molecular beam epitaxy (MBE) with a substrate temperature of 420°C, an InAs growth rate of 0.15 μm/s, and a V/III flux ratio of 12. The InAs was deposited on a 10 nm thick Ge layer grown on a 100 nm thick GaAs buffer and (100) GaAs substrate. For comparison, another set of samples were made where the InAs was deposited directly on the GaAs buffer layer under the same conditions. Then surface morphology was examined with an atomic-force microscope (AFM).

We have obtained experimental dependencies of the island density and of the average island size on monolayer (ML) coverage for the two material systems at hand. Based on this data, we have measured saturation island density of $1.3 \cdot 10^{11}$ cm^{-2} and $2 \cdot 10^{11}$ cm^{-2} for InAs on Ge and InAs on GaAs, respectively. For coverages higher than two monolayers InAs islands on Ge were on average larger than those on GaAs. InAs wetting layer thickness was found to be approximately 1.2 ML for islands on Ge and around 1.5 ML for samples with just GaAs buffer. We have also observed island phase evolution, which is quite different in the two systems. A distinct second island phase onset occurred at 2.5 ML coverage in InAs on GaAs system with several phases coexisting up to 3.5 monolayers, while InAs on Ge island distribution stayed relatively uniform throughout this coverage range.

Our data shows that in spite of very similar strain conditions, the islanding dynamics is significantly different in two systems under consideration. Our work suggests that surface diffusion plays an important role in island formation, and that the In adatom surface diffusion length is larger on Ge than GaAs. This fact is in good qualitative agreement with previously reported data for the In adatom binding energy on the Ge surface [1] and on the GaAs surface [2], since diffusion length is inversely proportional to the exponent of the adatom binding energy.

To summarize, we believe that this is the first observation and characterization of self-assembled InAs islands on Ge. Our comparison of islanding dynamics in this system with that of InAs islands on GaAs substantiated the importance of other factors besides the epitaxial strain state, such as surface diffusion, in island formation and evolution.

References

[1] D. H. Rich, et al., *Phys. Rev. B* , **41**, 3004 (1990).
[2] H. T. Dobbs, A. Zangwill and D. D. Vvedensky, *Surface Diffusion: Atomistic and Collective Processes*, Plenum Press, New York, 263 (1997).